SYMONS'S

MONTHLY

METEOROLOGICAL MAGAZINE.

CCI.] OCTOBER, 1882. [PRICE FOURPENCE, *or 5s. per ann. post free.*

METEOROLOGICAL BIBLIOGRAPHY.

I AM glad to be able to state that the compilation of the catalogue which is to be transmitted to the Signal Office of the United States for publication is rapidly approaching completion.

There is, however, one class of assistance which, though invited, has been rendered by very few persons. I am, of course, desirous of making the catalogue as nearly perfect as possible, but if authors who are also readers of this Magazine find that some of their works are not quoted, they will have to be referred to the following paragraphs which I reprint from the February number of this Magazine, and to which *only five replies* have been received!

"I therefore conclude by inviting authors, directors of Meteorological Institutes, and all others who may be willing to help, to send—

(1) Complete lists of Meteorological works published by them. If these are sent in MS., extremely legible (unmistakable) writing is indispensable; but, of course, printing is preferable.

(2) Copies of the papers or books. If any instructions as to the disposal of the works are sent, they shall be obeyed; if none are sent, the books will be added to my own library if a copy of each is not already there, or they will be distributed among the libraries of The Meteorological Society, The United States Signal Office, The Meteorological Office, The Société Météorologique de France, and The Scottish Meteorological Society."

This invitation is now eight months old, and I cannot *detain* the catalogue for chance arrivals; but, as two very important additions have yet to arrive from France, it is certain that it cannot be shipped before the middle of November, and therefore there is still time for any European author to accept the invitation.

G. J. SYMONS.

62, *Camden Square, N. W.*

THE BRITISH ASSOCIATION AT SOUTHAMPTON.

(*Continued from page* 123.)

On the effect of Wind on the draught of Chimneys, by PROF. LORD RAYLEIGH, F.R.S.

The author said that the draught diminished as the direction of the wind was more and more downwards, but did not go backwards until the inclination amounted to about 30 degrees. The maximum up-draught would occur, not, as was often supposed, with a direction of wind vertically upwards, but with one making an angle of about 30 degrees with the vertical. A chimney with a T piece at the top never produced an unfavourable effect on the up-draught, and only in one case failed to produce a favourable one. With a T piece to which was affixed vertical ends, every wind met with would have a favourable effect, and no wind known would have an unfavourable effect.

Professor De Chaumont thought that vertical ends increase the resistance of the up-draught, and described a chimney with a lamp-shade-like top and conical cap, with which it was impossible to get a down-draught.

Comparison of Magnetical and Meteorological Weather, by PROF. BALFOUR STEWART, F.R.S.

The author had compared the fluctuations of the daily range of temperature during 1871 and 1872, with the range of declination as photographically recorded at Kew. The daily ranges of temperature and those of declination were first smoothened by the process described by Mr. J. C. Bloxam, in his *Meteorology of Newport*—"Bloxamized" we may perhaps be permitted to say, and then the smoothened values were compared. The result seems to be that there is a slight similarity in the curves and that the temperature ranges follow the declination ranges at intervals of from 5 to 13 days according to the season.

On a supposed connexion between the heights of Rivers and the number of Spots on the Sun, by PROF. BALFOUR STEWART, F.R.S.

The author gave data respecting several rivers, and called especial attention to the Nile, which he stated reaches its greatest height in years of maximum sunspot prevalence, and taking the present as a maximum year he predicted that it would be a year of great rise of the Nile.

Report of the Committee on Meteoric Dust, read by PROF. SCHUSTER, F.R.S.

It will be remembered that the object of this Committee is, if possible, to collect the dust produced by the ignition and fusion of meteors and shooting stars when passing through the earth's atmosphere, As yet, however, they do not seem to have advanced very far, the principal fact which seems to have been quoted in their report was that M. Tissandier had found in meteoric dust particles of iron in a perfectly spherical form, and some dust from Sahara contained similar particles, which must at some time have been in a state of fusion.

Report of the Committee consisting of Professors Balfour Stewart, Thorpe, and Rücker, appointed at the York Meeting to Report on Methods of Calibrating Mercurial Thermometers, read by PROF. RÜCKER.

Thermometer tubes are in general of unequal bore in different parts, and the

ndications of the instruments will thus be erroneous, unless these irregularities are allowed for. If a short column of mercury broken off from the main mass in the bulb and tube be measured in different parts of the tube, its length will be greater in the narrower, and less in the wider parts. By means of such measurements the correction for the inequalities in the bore can be applied in two different ways distinguished as methods of calibration and correction respectively. In the first the length of the column of mercury is measured in various parts of the tube before the scale is etched on it, and the lengths of the divisions are then so adjusted as to make equal differences of scale readings correspond to equal volumes. In the second the tube is in the first instance furnished with a uniform scale, and a table of corrections is afterwards drawn up, by means of which the same end is attained as before. In either case the measurements have to be made systematically, and a number of different methods of performing the observations and calculations have from time to time been proposed. That used at Kew Observatory, Gay Lussac's, is the simplest of all, while the more elaborate methods have for the most part been proposed by German writers. The report consisted of a minute discussion of the relative merits of these various methods, the chief of which had been applied by the Committee to the same thermometer, so that the results could be readily compared. The measurements for this purpose were made in the Physical Laboratory of the Yorkshire College. The methods chiefly investigated were Gay Lussac's, Hällström's, Thiesen's, Marek's, Rudberg's, and Bessel's, both as modified by von Oettingen, and also with further modifications introduced by Professors Thorpe and Rücker.

Having given the above brief epitome of the subject, we have the pleasure of quoting from the *Chemical News* a full report of Professor Rücker's remarks:—

Report of the Committee on the Calibration of Mercurial Thermometers.

In drawing up the Report the Committee have desired to present it in the form in which it will be most generally useful. It is therefore divided into two parts. The first contains a brief outline of the various methods of calibration hitherto proposed, and a summary of the results arrived at with regard to them by the Committee. This portion, therefore, contains the facts necessary to enable a selection from the various methods to be made by persons intending to undertake the calibration or correction of a thermometer. The second consists of a fully worked-out example of each of the methods, together with critical and other remarks of a detailed character. This part will, it is hoped, be useful in facilitating the calculations required, more especially as references to the subject of calibration in English scientific works are rare and meagre.

The corrections for the inequalities in the bore of a thermometer tube may be applied in two different ways, viz., by *calibration* or *correction*. In the first the tube is studied before the scale is etched on it, and the divisions of the scale are adjusted so as to make equal differences of scale readings correspond to equal tube volumes. In the second the tube is furnished with a uniform scale, and a table of corrections is afterwards prepared by which the same result is attained. A high degree of excellence can be obtained by the former method, which is generally employed by the makers. If, however, great accuracy is desired, all thermometers require correction, and if an instrument has been previously calibrated, this process is rendered very laborious by the

varying lengths of the divisions which have to be allowed for in the calculations. The results, too, are probably, less accurate than they otherwise would be on account of the irregularity of the correction curves produced by the superposition of the errors of the tube and scale. The Committee, therefore, recommend the use of a uniform millimetre scale, and the employment of such tubes only as preliminary tests have shown to be of fairly uniform bore.

As all the methods of calibration and correction described depend upon the measurement of the length of columns of mercury in various parts of the tube, it is important to decide upon the best method of separating these "threads" (as they are called) from the main mass of mercury in the tube and bulb. In general it is in the first place necessary to make the mercury "run" from the bulb into the tube, so that a column of any length can be obtained when the thermometer is at the ordinary temperature. To effect this the instrument should be held in a vertical position with the bulb uppermost, and the lower end of the tube should be cautiously tapped against the table. If the mercury does not run, it is well, as a preliminary, to heat and cool the bulb several times. A change of temperature of a few degrees will generally suffice. The transference of the mercury from the bulb to the tube causes a vacuum bubble to appear in the former. If this is brought to the junction between the tube and bulb it is often possible, in a thermometer with a tolerably wide bore, to effect a disruption of the mercury at this point by a dexterous jerk, and thus to break off a thread of the desired length. It is, however, exceedingly difficult, if not impossible, to apply this method satisfactorily to instruments with narrow bores; and in all the experiments undertaken by the Committee the separation of the thread was effected by heat. Some writers recommend the use of the blowpipe flame, which appears unnecessarily risky. The Committee employed a small flame, about four or five millimetres high, obtained from the gas issuing from a narrow orifice at the extremity of a piece of glass tubing drawn out fine. Into this the thermometer was introduced, care being taken to heat the tube equally all round, and the rupture was effected at the point where the heat was applied. It is easy thus to break off threads to within a millimetre of the length desired. When great accuracy is important it is advisable first to break off a thread longer than that required, and then to separate from it a portion of the desired length. Greater steadiness of the mercurial column while the thermometer is being heated is thus attained. Many dozens of threads have thus been broken off within the experience of members of the Committee without a single breakage of the instruments experimented on.

Methods of calibration and correction may be divided into four classes.

The first class contains what may be called the *step by step* method which is due to Gay-Lussac. In it a thread of mercury is measured in a position A B, then shifted to B C, then to C D, and so on through the whole length of the tube, the corrections being deduced from the variations in length.

FIG. 1.

A B C D E F G

The second class contains *principal point* methods. In these a number of principal points separated by an equal number of scale divisions are selected. The corrections are determined for these by means of threads, the lengths of which are approximately equal to, or multiples of, the distance between two

consecutive principal parts. Several methods are included in this class. Hällström's, as described by Pfaundler, is a modification of Gay-Lussac's, in which an attempt is made to prevent the risk of the cumulation of errors inherent in the use of very short threads. Two threads are used, one twice, the other three times as long as the distance between two principal points. The first is measured in the positions (see Fig. 1) A C, B D, C E, &c., the other in the positions A D and B E only. From these measurements the corrections at A B C, &c., can be found.

In M. Thiesen's method (*Carl's Repertorium*, bd. xv.), the scale being divided into n parts by equidistant principal points, threads equal in length to 1, 2, 3 . . $n-1$ of these intervals are measured with the ends nearest the bulb, coincident in turn with as many of the selected points as possible, and hence the corrections are deduced. Marek (*Ibid.*, bd. xv.) has applied the method of least squares to the calculation of the corrections of a number of selected points.

When by any principal point method the scale has been divided into a number of parts, the relative volume values of which are known, it is of course possible to sub-divide these parts by a number of secondary points. In one method, however (Rudberg's), such sub-division is of the essence of the method, and it therefore constitutes the third class or method of *repeated sub-division*. Thus (see Fig. 1) the tube is first divided into two equal parts by measuring a thread of about half its volume when it occupies approximately the positions A D, D G. These parts are then sub-divided into three by measuring a thread about one-third of the length of the tube in the positions A C, C E, E G, B D, and D F, and the process can then be carried further.

The last class may be called that of *distributed point methods*. Of these there is only one example, viz., Bessel's. In it the threads are measured with the end nearest the bulb coincident in turn with each of a series of selected points, but as the lengths of the threads are, within wide limits, arbitrary, the other ends do not coincide with the principal points, but are distributed more or less unevenly over the scale.

In the modification of this method adopted by A. von Oettingen ("*Ueber die Correction der Thermometer*, Dorpat," 1865) eight or ten threads are used, and the corrections are finally found by a graphic method. The scale divisions being taken as abscissæ, and the corrections to be applied to them as ordinates, each thread furnishes a correction curve. The curve obtained by taking the mean of the ordinates of these is the final correction curve. This method is in the report subjected to full and detailed criticism. It is open to the objection that by it the ends of the tube are less accurately corrected than the centre. This is especially unfortunate. Thermometers are now often made with scales so open that it requires several to cover the whole range of temperature from 0° to 100° C. Each instrument therefore can have at the most but one fixed point, and to determine the value of a scale division in degrees it is necessary that each thermometer should overlap those above and below it, so that they can be compared over a considerable range of temperature. This range is, however, seldom more than one-fourth of that over which the scale of each thermometer extends, and thus any error which occurs in the determination of the relative value of this overlap in two instruments is magnified in its effects upon the absolute readings of each. It is, then, important that the ends of such thermometers shall be corrected with especial care, and Professors

Thorpe and Rücker have introduced some changes into Von Oettingen's method of procedure which diminish this defect. The two methods are fully compared in the Report.

In many methods of calibration and correction one or both ends of the thread are, when it is measured, assumed to occupy certain definite positions on the scale. The condition that both ends should occupy their theoretical position could only be fulfilled in a perfectly uniform tube ; otherwise, if satisfied in one part it would fail elsewhere. It is, however, often inconvenient even to comply with the condition that one end shall occupy a certain position. If the tube is graduated, and the position in question is indicated by a graduation, the breadth of this is often so considerable that the required accuracy of adjustment cannot be attained if the end of the thread is hidden behind it. Hence it is often better merely to bring the thread end to within a small but accurately measured distance of its theorotical position. The error thus committed can then be allowed for either by means of a second approximation, or by the use of a preliminary correction curve obtained by any simple method. The Report contains full details and examples of these two methods of procedure.

Formulæ are given which express the probable error of the correction of a principal point (E) in terms of the probable error of a thread length (e). If $E=m\,e$, the numbers in Table I. give the values of m^2 for ten principal points 4° apart, when the methods referred to are employed to find the corrections at them. These numbers are inversely proportional to the theoretical weights which should be assigned to the correction of a point determined by any method if it is to be combined with a similar correction determined by another method.

Thus in the case of Gay-Lussac's method, the value of the correction of a point is, *cæteris paribus*, proportional to the length of thread used in obtaining it. Rudberg's method corrects the instrument best in the middle—Gay-Lussac's at the ends. Thiesen's method has the advantage that the value of the corrections is uniform throughout the scale ; Hällström's the grave disadvantage that it is very irregular, and that the errors accumulate in an extraordinary way on two of the points.

TABLE I.

Squares of Probable Errors of Principal Points.

Point.	Gay-Lussac. Thread 2° long.	Gay-Lussac. Thread 4° long.	Rudberg.	Hällström.	Thiesen.	Bessel.
0	0·0	0·0	0 0	0·0	0·00	0 00
1	1·8	0·9	1·4	1·1	0·18	0·10
2	3·2	1·6	1·8	0·8	0·18	0·10
3	4·2	2·1	0·7	1·1	0·18	0·10
4	4·8	2·4	0·6	1·2	0·18	0·09
5	5·0	2·5	0·5	2·5	0·18	0·09
6	4 8	2·4	0·6	1·2	0·18	0·09
7	4·2	2·1	0·7	4·3	0·18	0·10
8	3·2	1·6	1 8	0·8	0·18	0·10
9	1 8	0·9	1·4	6·5	0·18	0·10
10	0·0	0·0	0·0	0 0	0·00	0·00

It must be remembered that the numbers in this Table apply only to the case of the determination of ten principal points, and that in calculating them no allowance is made for inaccuracies introduced by assumptions, which are only approximately true, made in the methods themselves.

The experimental work of the Committee has been performed upon twelve thermometers. Two sets of three belonging to Professors Thorpe and Rücker were made by Casella. The other two sets were made in the Kew Observatory and in the Physical Laboratory of the Owens College respectively. The length of a degree in the different instruments varied from 9 to 13 mm., and may therefore, in round numbers, be taken as equal to a centimetre.

The Kew Thermometers were calibrated according to Welsh's (Gay-Lussac's) method, a good dividing engine being employed. After the scale was etched, the same instrument was employed to make all the measurements necessary for the application of Bessel's method to the thermometer. The result of this severe test was reported to Section A last year, viz., that the maximum error barely exceeded 0·01°, and in two of the thermometers fell much below this amount.

The Committee have also tested the various methods by applying them all to the same thermometer, an instrument reading from 98° C to 142° C. The measurements were made in the Physical Laboratory of the Yorkshire College, partly by Professor Rücker, partly by Mr. W. Heaton, Demonstrator in the Clarendon Laboratory of the University of Oxford, who spent some time in Leeds for the purpose of assisting in this rather laborious task. Gay-Lussac's method was applied three times, the thread lengths being 1·6°, 2·0°, and 4·0° respectively. The curve obtained by means of the thread 2·0° long was used as above explained as a preliminary curve to allow for the errors introduced in the other methods by the fact that the thread ends did not always occupy their theoretical positions.

The instrument employed was that devised by Mr. F. D. Brown, and described by him in a recent number of the *Philosophical Magazine* (June, 1882). Readings could be made on the vernier to 0·1 mm., and by estimation to 0·02 or 0·03 mm. The probable error of the measures made for the application of Bessel's method, 138 in number, was 0·25 mm. The Committee thought it well to employ this instrument, as if satisfactory results were obtained its comparative simplicity and cheapness would enable many persons to correct their thermometers who had not the opportunity of using the dividing engine. The result of the investigation showed that it is capable of giving very good results. The following table gives in thousandths of a degree the corrections obtained for the principal points by the methods indicated. Rudberg's method cannot be directly compared with the others, as it was used to find the corrections at 12 points.

TABLE II.

Corrections given by Different Methods in Terms of 0·001°.

	Gay-Lussac. Thread Length.			Hällström.	Thiesen.	Marek.	Bessel.
	1·6°.	2·0°.	4·0°.				
100 ...	0	0	0	0	0	0	0
104 ...	121	120	116	120	121	—	120
108 ...	155	155	151	153	156	155	151
112 ...	106	109	104	107	109	—	104
116 ...	108	116	113	115	117	117	115
120 ...	130	136	135	137	138	—	135
124 ...	106	112	111	109	113	112	109
128 ...	108	111	111	114	112	—	108
132 ...	56	60	61	56	61	62	54
136 ...	2	10	12	13	10	—	4
140 ...	0	0	0	0	0	0	0

In estimating the value of the agreements between the various columns in this table, it must be remembered that whereas the two first Gay-Lussac corrections and those given by Bessel's method are quite independent of the others, observations on the same threads were employed in the other methods. All the measurements, for instance, worked up according to Marek's formulæ, were also employed in the calculations required in Thiesen's method. It will be seen that the difference between the corrections for the same point only in one instance exceeds 0·01°.

On the other hand, the amount of labour involved in the different methods is very different. Gay-Lussac's method can be applied in a few hours; the observations and calculations necessary for Bessel's occupy six or seven days.

The following table gives the number of actual measurements required in such method.

TABLE III.

Method.	No. of Measures Required. (1) Principal Corrctns.	(2) Preliminary Curve.	(3) Total.	No. of Points. Corrd. (1) Principal Corrections.	(2) Total.
Gay-Lussac I...	26	—	26	26	26
,, II...	20	—	20	20	20
,, III...	10	20	30	10	20
Hällström	11	20	31	10	20
Thiesen	54	20	74	10	20
Marek.....	14	20	34	5	20
Rudberg.....	15	20	35	12	31
Bessel	138	—	138	148	148

A detailed discussion of the results arrived at by the different methods, awards, on the whole, the palm to Bessel's, but the Committee consider that equally good results can be obtained with much less labour by repeating Gay-Lussac's method with two or three threads of different lengths, and taking the mean of the curves so obtained. Thus, the mean of the numbers in the first two columns of Table II. nowhere differs from the corresponding number in the last column by 0·005° (0·05 mm.).

The Committee, for convenience, finally define three standards of accuracy, viz., that the corrected scale shall at no point be in error by 0·1, 0·05, and 0·02 mm. respectively. In the thermometer used these would correspond to about 0·01°, 0·005°, and 0·002°. They consider that 0·05 mm. is about the limit of the error of an unassisted-eye reading, and that the second standard is therefore that which will be most generally aimed at for very accurate work. The Report contains details of the methods which the Committee think suited to attain each of these standards with the least trouble. In brief, they state that the first can be reached by a calibration by Gay-Lussac's method conducted with a dividing engine, the second by correcting according to Bessel's method or by the mean of two of Gay-Lussac's curves when the measurements are made with Mr. Brown's instrument, the third can be obtained only by the most elaborate methods and apparatus. On the whole, therefore, the result of the investigation is in favour of the repetition of the less elaborate rather than of the use of the more theoretically perfect methods.

[Two very interesting papers upon the formation of hail were read by Prof. Silvanus P. Thompson, the first a translation of Schwedoff's pamphlet, "*Sur l'Origine de la Grêle*," and the second by himself. As, irrespective of the theory in the first, both contain much valuable information, we have great pleasure in stating that Professor Thompson has allowed us to print both *in extenso*.]

On the Origin of Hail. By PROF. THÉODORE SCHWEDOFF, *of Odessa.*

The efforts of savants, including some of the most eminent, to elucidate the problems relating to the origin of hail, are generally well known; but if we compare our present knowledge on this subject with that of two centuries ago, we are astonished at the utter lack of progress. Without going into details, the most salient facts relative to this phenomenon do not adapt themselves to any explanation by the theories propounded down to the present day.

Let us begin by considering the size of hailstones.

In 1819, the hailstones fell so as to penetrate the roofs of houses, and many of them measured as much as 37 centimetres (14½ in.) in circumference. (4¼ in. in diameter). In 1846, at Utrecht, there fell a hailstone measuring 65 centims. (26 in.) in circumference, (5¾ in. in diameter), Hailstones that fell at Kivacht (Zealand) in 1863, penetrated not only the roofs, but also the ceilings. A similar hailstone, after coming through the roof, wounded a man who was beneath so severely, that he kept his bed for more than a month. This hailstone, picked up after its fall, still weighed six kilogrammes (13 lbs.). This fact can be authenticated. A still more remarkable fact is often cited, namely, the fall of a block of ice in Hungary, on May 8th, 1802. This block was three feet long, by two feet wide. It is true that this fact is called in question by certain savants, but simply because it does not square with the supposition that hailstones are formed in our atmosphere. But on this reasoning, neither the hailstone weighing six kilogrammes (13 lbs), nor that sixty-five centimetres (26 inches) in circumference, should be more authentic, for they do not agree any better with the hypothesis of the atmospheric origin of hail.

To turn the flank of this difficulty some have had recourse to ascending ærial currents, which, while holding a hailstone in suspension, bring it the vapour and the cold necessary for the congelation of this vapour. Without denying the existence of such currents, I only observe that the facts reveal no connexion whatever between the fall of hail and atmospheric currents. M. Abich, who has had many opportunities of observing hail, and who has made a profound study of it, finds that hail does not depend upon the rise or fall of barometric pressure, which must, however, be intimately connected with the direction of atmospheric currents. I will cite only one case of this kind. On the 14th of January, 1860, on the Atlantic, at three days' distance from the Cape of Good Hope, there fell hailstones as large as half a brick, though the barometer was almost stationary, and nothing presaged a storm. To sustain in suspension such a hailstone, however, the velocity of the ascending currents must have been from 30 to 40 metres per second (70 to 90 miles per hour), and the lowering of the barometer that would have resulted from it could not have been less that 10 millimetres (0·39 in.)

Let us pass to the quantity of ice precipitated during a hailstorm. In 1876, at Mavrino, in Italy, the thickness of the layer of ice was from 10 to 20 centimetres (4 to 8 in.) It was from 22 to 30 centimetres (9 to 12 in.) in 1818, in

the island of Stronsa in Scotland ; upwards of 25 centimetres (10 in.) in 1863, at Kivacht, in Zealand ; upwards of 30 centimetres (12 in.) in 1869, in the Caucasus ; upwards of 40 centimetres (15 in.) in 1830, in Mexico. Now the true atmospheric deposits, rain and snow, never attain the tenth part of this quantity. The most disastrous tropical deluges rarely attain 2·5 centimetres (1·00 in.)*, even if they last several successive hours, and hail never lasts more than 20 minutes. Besides, it is possible to show by calculation that the layer of water that the atmosphere would be capable of depositing, could not possibly, under the most advantageous conditions, exceed 4 to 5 centimetres (1½ to 2 inches) in thickness, whatever the hypothesis that might be suggested about the distribution of vapour in the various strata of the atmosphere before and after the fall of the hail.

Nor is the temperature of hailstones more easily explained. We know that the temperature of freshly frozen ice is equal to zero (Centigrade) whatever may be the temperature of the surrounding medium. Even in the case where the water, still remaining liquid, is cooled below zero, the ice which results therefrom is never at any other than zero temperature (32° F.). It is quite otherwise with hail. Hail that fell in Alsace in 1877 had a temperature of —2° to —4° C. (28°·4 to 24°·8 F.); that of the air being +27° C. (80°·6 F.) Cailletet found the temperature of hail that fell in the month of July equal to —9° C. (15°·8 F.). According to Boussingault, the temperature of hail that fell in 1875 was —13° C. (8°·6 F.) ; that of the air being equal to +26° C. (78°·8 F.)

(To be continued.)

RADIANT HEAT.—Some interesting experiments have recently been made in connection with this subject by Professor S. P. Langley, of the Alleghany Observatory. He finds, as one of the results of these experiments carried on at Mount Whitney, that the true solar constant or amount of heat sent to the earth is one-half greater than that determined by Pouillet and by Herschel near the sea level, and even greater than the latest values assigned by M. Violle. But the temperature of space, on the other hand, is lower than that assigned by M. Pouillet. If the atmosphere of the earth were withdrawn, the temperature of the latter would greatly fall, even though the sun's radiant heat were materially greater than it is. Mr. Langley believes that this temperature under such circumstances would be —50° Fahr., that is, that mercury would remain a solid under the vertical rays of a tropical sun if radiation into space were wholly unchecked, or even if, the atmosphere existing, it let radiations of all wave lengths pass out as easily as they come in. It is not merely by the absorption of the air but by the selective quality of this absorption that the actual surface temperature of the earth is maintained. Without this comparatively little known function, it appears doubtful whether, even though the air supported respiration and combustion as now, life could be maintained on this planet. The temperature of a planet, consequently, probably depends far less on its neighbourhood to or remoteness from the sun than upon the constitution of its gaseous envelope, and it is perhaps not too much to say, that we could approximately indicate already the constitution of an atmosphere which could make Mercury a colder planet than the earth, or Neptune as warm and habitable a one.

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* Surely a misprint for 25 centimetres, or 10 in.—*Ed. M. M.*

THE PAST SUMMER.

To the Editor of the Meteorological Magazine.

SIR,—In a letter which appeared in the March number of your Magazine, Mr. Brumham wrote as follows: "In every case when extremely high pressure has occurred about the end of December, in January, or early in February, the following summer has been remarkably hot, or the harvest remarkably good. In many instances both occurred." And then, after giving examples, he adds:—"So we may expect a warm summer and a good harvest to gladden us this year." I suppose it is hardly necessary to adduce figures to prove that the late summer has not been "remarkably hot," or even "warm." But two sentences from the "Report on the weather over the British islands during the four weeks which ended August 28th, 1882," appended to the official weekly Weather Report published in the *Times* of yesterday may be worth quoting as the words of one whose duty it has been to collect and tabulate the readings of the thermometer from about fifty representative British stations day by day and week by week:—"It was reserved to the second week of August," so he writes, "to produce the only temperatures (*i.e.*, maximum temperatures) above 80° which have been recorded over England this summer, and even this happened only once over our southern counties." And further on in the same report he speaks of—"Ten days of moderately fine weather as the only period of the year worthy of the name of summer at all."

This is the third failure on the part of Mr. Brumham to which I have had to call attention within the year; and, while I fully recognise the indefatigable industry and perseverance displayed by him, I would again ask, as I have asked before, what practical advantage can be expected from research of this kind? Mr. Brumham's predictions, founded as they are upon the simple observation of a few cases of sequences, unsupported by any theory or antecedent probability, seem to me to belong to the same category as the weather rule (devoutly believed in by thousands of persons in this country), according to which a wet Friday is inevitably followed by a wet Sunday. In other words they are founded, as the result has shown in the three last, as in several other, cases, on an insufficient induction of instances. In the case of the Friday and Sunday weather rule, any one who will take the trouble to do so may convince himself of its fallacy by observations extending at furthest over three or four months (I have known it hold true for nine or ten consecutive weeks). In the case of Mr. Brumham's rules a longer period is necessarily required in order to demonstrate their fallacy. In the meantime, even though a sequence which Mr. Brumham has found to hold, say five or six times, should hold a sixth or seventh time, it is not to be hastily assumed that he has established anything more than a somewhat remarkable coincidence.

G. T. RYVES, F.M.S.

Tean Vicarage, Stoke-on-Trent, Sept. 8th, 1882.

AURORA BOREALIS OF OCTOBER 2ND.

To the Editor of the Meteorological Magazine.

SIR,—There has been a rather remarkable display of Aurora Borealis here this evening. I first saw it at 7 p.m., when the greater part of the sky was covered with patches of white light, flashing very rapidly from N. to S. In the S.E. was a large oval patch of light, steady, and very bright. It was about 30 degrees above the horizon, and moved slowly until it was due S. of this place, at 7.39 p.m., when it went out as suddenly as if it had been blown out. Did any one else observe this? After it had disappeared, the flashing in the northern part of the sky ceased, and only the usual auroral arch remained.—I remain, Sir, yours truly,

W. C. HUGHES, F.M.S.

2, St. Martin's-square, Scarborough, Oct. 2nd, 1882.

SOLAR HALOS AND THE WEATHER.

To the Editor of the Meteorological Magazine.

SIR,—During many months past I have noticed a relation between solar halos and the subsequent weather at this station, I have found that drizzle and rain came on invariably between six and twenty-four hours; this would, no doubt, be an extension of the state of the upper atmosphere to a lower level. If this forecast were always as good a one as I have found it since I first noticed it, it would take a high rank in practical weather lore. Perhaps some observer may have noticed it and determined percentages of success.

H. GARRETT.

Ivybank, Highfield, Southampton, Oct. 4th, 1882.

[It would probably be useful if our readers generally would state their experience on this subject. Recollecting that it was mentioned in a rather scarce pamphlet by Mr. E. J. Lowe, F.R.S., ("Prognostications of the Weather, or Signs of Atmospheric Changes," London, 1849,) we have copied out the paragraphs bearing upon it:—

"It is said to be a sign of rain when the sun or moon is surrounded by a halo." During the last eight years, more than 300 solar and lunar halos have been registered at Highfield House, Nottingham; and in this large number, fine weather has more frequently followed than otherwise. From the 1st of November, 1840, to the 1st of November, 1848, 204 solar halos were observed; 133 of these were followed by 24 hours' fine weather, and the remaining 71 by rain. (If the rain fallen in the 24 hours is not sufficient to be measured in the gauge, the day is accounted fine.) In the same time, 102 lunar halos were recorded, 51 being followed by fine weather, and 51 by rain. Therefore, in these 306 halos, we find 184 followed by fine weather and 122 by rain." . . . "My friend, James G. Tatem, Esq., (of High Wycombe,) who has been a zealous observer of atmospheric changes for the last thirty years, noticed since 1823, 109 lunar halos; 54 were followed by rain and 55 by fine weather."]—ED. *Met. Mag.*

SUPPLEMENTARY TABLE OF RAINFALL, SEPTEMBER, 1882.

[For the Counties, Latitudes, and Longitudes of most of these Stations, see *Met. Mag.*, Vol. XIV., pp. 10 & 11.]

Div.	STATION.	Total Rain.	Div.	STATION.	Total Rain.
		in.			in.
II.	Dorking, Abinger	3·12	XI.	Solva	4·66
,,	Margate, Birchington...	3·98	,,	Castle Malgwyn	5·43
,,	Littlehampton	2·21	,,	Rhayader, Nantgwillt..	3·63
,,	St. Leonards	3·37	,,	Carno, Tybritle	3·33
,,	Hailsham	3·40	,,	Corwen, Rhug	2·33
,,	I. of W., St. Lawrence.	2·62	,,	Port Madoc	3·62
,,	Alton, Ashdell.....	2·58	,,	I. of Man, Douglas	3·92
III.	Great Missenden.....	2·70	XII.	Carsphairn	5·58
,,	Winslow, Addington ...	2·55	,,	Melrose, Abbey Gate...	2·24
,,	Oxford, Magdalen Col...	2·08	XIII.	N. Esk Res. [Penicuick]	3·10
,,	Northampton	3·10	XIV.	Ayr, Cassillis House ...	3·34
,,	Cambridge, Beech Ho...	1·93	,,	Glasgow, Queen's Park.	3·46
IV.	Southend	2·73	XV.	Islay, Gruinart School..	5·36
,,	Harlow, Sheering	2·56	XVI.	St.Andrews,NewtonBk	1·44
,,	Diss	2·40	,,	Aberfeldy H.R.S.	...
,,	Swaffham	3·01	,,	Dalnaspidal	4·78
,,	Hindringham	2·73	XVII.	Tomintoul.....	...
V.	Salisbury, Alderbury...	2·88	,,	Keith H.R.S.	3·64
,,	Calne, Compton Bassett	2·60	XVIII.	Forres H.R.S.	5·28
,,	Beaminster Vicarage ...	2·82	,,	Strome Ferry H.R.S....	6·28
,,	Ashburton, Holne Vic..	5·33	,,	Lochbroom	3·72
,,	Torrington, Langtree W.	4·93	,,	Tain, Springfield.....	3·56
,,	Lynmouth, Glenthorne.	3·68	,,	Loch Shiel, Glenaladale	7·19
,,	St. Austell, Cosgarne...	...	XIX.	Lairg H.R.S.	...
,,	Taunton, Fullands	2·78	,,	Forsinard H.R.S.	5·60
VI.	Bristol, Clifton	2·70	,,	Watten H.R.S.	2·66
,,	Ross	3·02	XX.	Fermoy, Glenville	2·93
,,	Wem, Sansaw Hall.....	2·01	,,	Tralee, Castlemorris ...	3·63
,,	Cheadle, The Heath Ho.	2·16	,,	Cahir, Tubrid	1·35
,,	Worcester, Diglis Lock	2·15	,,	Newcastle West	2·07
,,	Coventry, Coundon	2·73	,,	Kilrush	2·63
VII.	Melton, Coston	2·61	,,	Corofin	2·04
,,	Ketton Hall [Stamford]	2·25	XXI.	Kilkenny, Butler House	...
,,	Horncastle, Bucknall...	2·16	,,	Carlow, Browne's Hill..	3·16
VIII.	Macclesfield, The Park.	1·99	,,	Navan, Balrath	3·98
,,	Walton-on-the-Hill.....	2·78	,,	Athlone, Twyford	2·19
,,	Broughton-in-Furness ..	3·46	XXII.	Mullingar, Belvedere ...	1·84
IX.	Wakefield, Stanley Vic.	2·07	,,	Clifden, Kylemore	...
,,	Ripon, Mickley	2·40	,,	Crossmolina, Enniscoe..	3·44
,,	Scarborough.....	1·08	XXIII.	Carrick-on-Shannon ...	3·12
,,	East Layton[Darlington]	1·81	,,	Dowra	2·49
,,	Middleton, Mickleton..	2·80	,,	Rockcorry.....	2·82
X.	Haltwhistle, Unthank..	1·74	,,	Warrenpoint	4·06
,,	Carlisle, St. James Rd...	1·86	,,	Newtownards	3·32
,,	Shap, Copy Hill	2·50	,,	Belfast, New Barnsley .	4·54
XI.	Llanfrechfa Grange	4·23	,,	Bushmills	4·15
,,	Llandovery	3·17	,,	Buncrana	5·18

SEPTEMBER, 1882.

Div		STATIONS. [The Roman numerals denote the division of the Annual Tables to which each station belongs.]	RAINFALL. Total Fall.	Difference from average 1870–9	Greatest Fall in 24 hours. Dpth	Date	Days on which ·01 or more fell.	TEMPERATURE. Max. Deg.	Date.	Min. Deg.	Date.	No. of Nights below 32°. In shade.	On grass.
			inches	inches.	in.								
I.	ENGLAND.	London (Camden Square) ...	2·39	— ·11	·86	28	9	70·6	3	37·8	15	0	0
II.		Maidstone (Hunton Court)...	3·42	+ 1·11	·80	19	15	...	...	...	...	...	...
,,		Strathfield Turgiss	2·55	+ ·25	1·00	19	12	69·6	3	32·5	15	0	6
III.		Hitchin	1·78	— ·70	·48	19	16	66·0	3	35·0	14	0	...
,,		Banbury	...	...	...	...	...	...	...	...	...	...	...
IV.		Bury St. Edmunds (Culford)	2·44	— ·34	·56	28	18	70·0	3	35·0	14	..	...
,,		Norwich (Cossey)	2·38	— ·70	·56	28	16	71·0	10	38·0	15	...	...
V.		Bridport	3·25	...	·98	28	14	...	..	...	...	...	...
,,		Barnstaple.....	3·94	— ·34	1·13	14	15	83·0	20	40·0	19	...	...
,,		Bodmin	5·28	+ ·04	1·54	26	20	70·0	8	40·0	13	0	0
VI.		Cirencester	3·25	+ ·11	·69	1	16	..	...	...	...	...	...
,,		ChurchStretton(Woolstaston)	2·74	— ·73	·44	26	21	65·5	16	41·0	13	0	0
,,		Tenbury (Orleton)	3·14	— ·21	·58	28	20	68·2	8	31·8	15	2	4
VII.		Leicester	2·51	...	·64	19	18	69·5	8	34·0	15	0	2
,,		Boston	3·34	+ ·73	·73	12	11	67·0	3	38·0	16	0	...
,,		Grimsby.....	1·68	— 1·39	·34	12	14	69·0	1	39·0	15	0	...
,,		Hesley Hall [Tickhill].....	1·11	...	·33	29	14	70·0	8	32·0	15	1	...
VIII.		Manchester (Ardwick).....	1·78	— 1·99	·40	28	15	66·0	10	42·0	12	0	...
IX.		Wetherby (Ribstone Hall) ..	1·81	— 1·27	·42	4	11	...	...	...	...	...	...
,,		Skipton (Arncliffe)	3·66	— 1·92	·62	1	22	67·0	7	33·0	11	0	...
X.		North Shields	..	...	...	...	..	...	...	...	...	...	...
,,		Borrowdale (Seathwaite).....	8·18	— 5·04	2·35	1	19	...	...	...	...	..	...
XI.	WALES.	Cardiff (Ely).....	3·65	— 1·15	·90	1	14	...	...	...	...	...	...
,,		Haverfordwest	4·54	— ·51	1·04	25	17	65·0	8, 30	33·9	12	0	4
,,		Plinlimmon (Cwmsymlog) ...	5·56	...	1·12	1	20	...	...	...	...	...	...
,,		Llandudno.....	1·98	— 1·77	·33	17	18	67·2	1	42·0	14	0	...
XII.		Cargen [Dumfries]	2·18	— 2·23	1·11	1	13	67·4	3	35·2	12	0	...
,,		Hawick	2·04	— ·60	·58	1	13	...	...	..	...	...	...
XIV.		Douglas Castle (Newmains)	3·29	— 1·11	·72	1	16	...	...	...	...	...	.
XV.		Lochgilphead (Kilmory).....	7·61	+ 1·85	1·89	1	24	...	...	32·0	30	1	...
,,		Appin (Airds)	7·43	...	...	...	...	...	...	...	...	...	...
,,		Mull (Quinish).....	7·37	...	1·24	27	24	...	...	...	.	...	...
XVI.		Loch Leven Sluices	2·40	— ·83	1·00	2	8	...	...	...	...	...	...
,,		Arbroath	1·69	— 1·38	·55	1	12	67·0	2	37·0	12	0	...
XVII.		Braemar	3·09	— ·85	·59	27	20	62·0	9	27·0	12	5	14
,,		Aberdeen	3·04	...	·86	1	17	65·0	2, 7	34·0	11*b*	0	...
XVIII		Skye (Sligachan)	8·46	...	1·90	10	25	...	...	...	...	...	...
,,		Culloden	6·48	+ 3·58	1·95	15	15	64·1	9	36·2	29	0	4
XIX.		Dunrobin	3·60	...	·76	1	18	65·0	7	37·0	12	0	...
,,		Orkney (Sandwick)..... ..	3·04	— ·45	·63	9	16	64·2	9	40·0	12	0	0
XX.		Cork (Blackrock)	2·24	— 1·91	·44	30	16	78·0	9	34·0	27	0	...
,,		Dromore Castle	3·19	...	·54	2	15	69·0	4	39·0	24*e*	0	...
,,		Waterford (Brook Lodge) ...	3·30	...	·46	26	16	64·0	13*a*	36·0	28	0	...
,,		Killaloe	3·31	...	·94	1	17	74·0	9	33·0	26	0	...
XXI.		Portarlington	1·80	— 1·38	·55	26	19	68·0	1	36·0	13	0	...
,,		Dublin (Monkstown)	...	...	...	...	...	...	...	...	...	...	...
XXII.		Ballinasloe	1·51	...	·43	1	17	66·0	9	36·0	29*d*	0	...
XXIII.		Waringstown	4·98	+ 1·63	1·48	26	19	70·0	8	34·0	11	0	2
,,		Londonderry...	...	...	...	...	...	...	...	...	...	...	...
,,		Omagh (Edenfel)	4·57	+ ·53	1·50	26	18	67·0	24	32·0	11	1	5

+ Shows that the fall was above the average ; — that it was below it.

a And 14, 21. *b* And 28. *c* And 25, 26, 27. *d* And 30.

METEOROLOGICAL NOTES ON SEPTEMBER.

ABBREVIATIONS.—Bar. for Barometer; Ther. for Thermometer; Max. for Maximum; Min. for Minimum; T for Thunder; L for Lightning; T S for Thunderstorm; R for Rain; H for Hail; S for Snow.

ENGLAND.

STRATHFIELD TURGISS.—The weather of the month was rather unsettled, the harvest was on the whole satisfactory, but the yield varies much, there is an average of wheat, an excess of oats, and a deficiency of barley. T on 11th and 13th.

CULFORD.—Wet and unsettled till the 21st, followed by a very fine week with heavy dews. Potato crop free from disease. Strong breeze on 2nd; distant T on 13th; frost on grass on 14th; L on 19th; heavy dew on 25th.

COSSEY.—A cold month, making harvest slow, but five consecutive fine days from 21st to 25th, inclusive, enabled many farmers to finish.

BODMIN.—A cold, rainy, and unseasonable month; mean temp. 55°·3.

CIRENCESTER.—Not a good month for gathering in the remainder of the harvest.

WOOLSTASTON.—A favourable month on the whole for harvest operations; mean temp. 53°·1.

ORLETON.—The first 10 days were warm and generally fine, but the remainder of the month was very cold, cloudy, and damp, with frequent R, and very few fine days. A late and difficult harvest. The mean temp. was nearly 3° below the average, and lower than that of any other September during the last 21 years, except that of 1877; the bar. was generally low after the 10th, but the fluctuations were not great, T was heard on the 3rd and 12th; frost occurred on the mornings of the 12th, 13th, 15th, and 16th, and fogs on several mornings in the middle of the month.

LEICESTER.—TS on 3rd; white frosts on 8th, 15th, and 16th.

GRIMSBY.—Distant T on 27th.

WALES.

HAVERFORDWEST.—The stormy wet weather of August was continued into September with very high tides; fine on the whole, but with occasional wet days from 3rd to 19th, the nights being cold from 6th to 14th, and again on the 17th and 18th; very fine weather from the 16th to 24th, and from 25th to the end very wet, stormy and mild; solar halo on the 8th; grand display of sheet L to S.E. from 8 p.m. till midnight on 12th, and distant T to the extreme S.

LLANDUDNO.—The mean temp. of September was 3°·4 below the average, and though the month was showery, the aggregate rainfall was nearly 50 per cent. below the average. There was likewise a deficiency of bright sunshine, the number of hours in the month amounting only to 101·8; nevertheless, there were some remarkably fine days.

SCOTLAND.

CARGEN.—A fine harvest month on the whole. Crops well secured; all crops in this immediate neighbourhood above the average; mean temp. 54°·7, 0°·2 below the average; T on 13th.

HAWICK.—A remarkably mild month; several peals of T on the afternoon of 27th. The crops in this district are all good.

ABERDEEN.—Except in the early part of the month, when heavy R fell for three days, the weather was very favourable for harvest operations. Rainfall fully 0·50 in. below the average; T and L on 2nd; brilliant aurora on 5th, and faint aurora on 11th; heavy dew on 28th and 29th.

SLIGACHAN.—A cold, wet, ungenial month; only six dry days; one of the worst haymaking seasons I have known, a great deal yet unsecured; very heavy R on the morning of the 10th, 1·90 in. fell in little over six hours.

SANDWICK.—The rainfall in September was rather above the average, but the weather was in general favourable for harvest work, and there was no equinoctial gale; one, however, came on October 1st, when it blew 60 miles an hour; T on 7th; auroræ on 4th, 5th, 11th, 17th, and 18th.

IRELAND.

DROMORE.—A good harvest month on the whole. Oats well got in, a crop considerably above the average.

WATERFORD.—The early part of the month was favourable for getting in the harvest, but a break occurred on the 23rd, and the remainder of the month was wet and unsettled, gale from S.W. on the 30th, T on 12th with H.

KILLALOE.—A fairly average harvest month, and autumn work more successful than was hoped for in August. Mean temp. 55°·1, being below the average of the last five years.

EDENFEL.—September was a seasonable month, the rainfall, though in the aggregate considerably above the average, having nearly all fallen on six days, notably on the 1st and 26th, when 1·22 in. and 1·50 in. fell respectively.

HAILSTORM ON SEPTEMBER 12TH.

To the Editor of the Meteorological Magazine.

SIR,—On 12th inst., at 2.15 p.m., we had a remarkable hailstorm—in 20 minutes 0·20 in. of hailstones fell, of large size; my lawn was perfectly white for nearly an hour; geraniums, mangold leaves, &c., cut to pieces. Before 3 p.m. 0·36 in. fell. The thermometer in the shade did not fall below 54°. At a point only 1200 yards from my gauge not one single drop of rain or a hailstone fell.

Yours faithfully,

R. H. LIPSCOMB.

East Budleigh, Budleigh Salterton, Sep. 21st, 1882.

MULTIPLE RAINBOWS.

To the Editor of the Meteorological Magazine.

SIR,—I did not observe the rainbow referred to by Mr. Lawrence, but I send the following notes on the subject, in case you think them worth publishing: On 24th July, 1882, at 7.10 p.m., and on 19th May, 1881, from 6 p.m. to 6.10 p.m., unusually bright and perfect bows were noticed here; in the latter case especially the colours were remarkably well defined. I give the colours below; the supernumerary bows followed immediately below the primary, and were narrow:—

24th July, 1882.		19th May, 1881.	
Green, Yellow, Red	*Outer.*	Green, Yellow, Red	*Outer.*
Red, Yellow, Green, Blue	*Primary.*	Red, Yellow, Green, Blue	*Primary.*
Crimson, Green	(1) *Supernumerary*	Red, Yellow, Green	(1) *Supernumerary.*
Crimson, Green	(2) *Supernumerary.*	Red	(2) *Supernumerary.*

Yours faithfully,

E. T. DOWSON.

Geldeston, Beccles, August 30th, 1882.

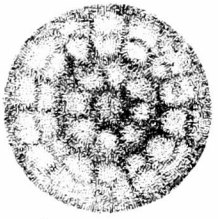

Fig. 1

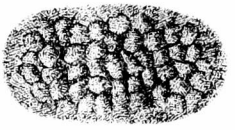

Fig. 2.

Fig. 3.

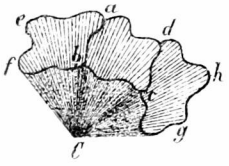

Fig. 4.

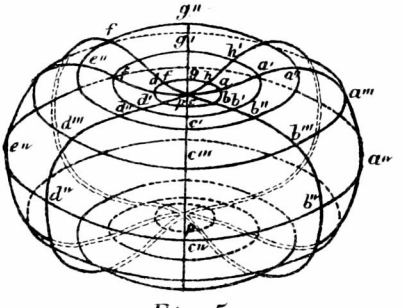

Fig. 5.

Fig. 6.

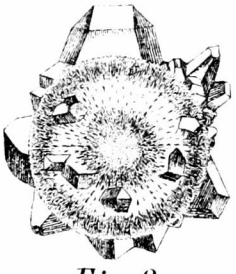

Fig. 8

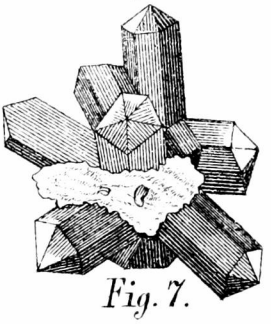

Fig. 7.

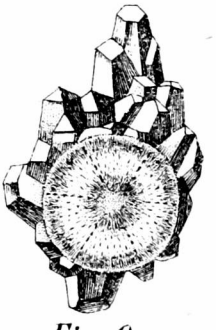

Fig. 9.

1. Observed by Abich in the Caucasus.
2. „ „ „
3. „ „ „
4. Segment of Fig. 1
5. Illustrative of Schwedoff's theory of formation.
6. Observed by Neuchel at Tiflis.
7. „ „ Secchi in Italy.
8. „ „ Abich in the Caucasus.
9. „ „ „ „ „